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ABSTRACT

Through a review of the literature, this paper centers on the temporal analysis of communication behaviors in the study of social interaction. It argues that the choice of one or another temporal model of analysis and its underlying assumptions is highly related to the conclusions about social interaction that are found by the researcher. Although the temporal methods of analysis proved valuable in the study of social interaction, the different research models have built-in limitations that need to be taken into account by those who use them. (RB)

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Temporal Models of Communicative and Social Interactive Behavior: Implications of Different Research Models

Whereas experimental and naturalistic research methods have long been viewed as exclusive, more recently researchers have combined the two by manipulating independent variables and allowing dependent variables to fluctuate naturalistically. The framework provided by this form of research design has lent itself very strongly to the use of temporal methods of behavior analysis. This paper will center on the temporal analysis of communication behaviors in the study of social interaction. It will be argued here that the choice of one or another temporal model of analysis and its underlying assumptions is highly related to the conclusions about social interaction that are found by the researcher.

Social interaction research attempts to look at the behaviors of people, the effects of one behavior on another, and the resulting patterns of behaviors. To look adequately at behavioral interaction it is necessary to stretch the process over time and gain some picture of the patterns of behavior that develop and change with social communication. Several experimenters have shown that time plays a key role in the social interaction process and that it can be linked to other important variables.[1] For example, Goldman-Eisler (1967) has noted the role of temporal duration in the thought processes when she argued that time gives a behavioral definition to the relationship between lexical choices and the though processes. Dittmann (1967) has studied the temporal placement of linguistic units within phonemic clauses and following the lead of Lounsbury has argued that a high statistical uncertainty (in the information theory sense) is manifest in the placement of primary words in clauses. Finally, the work of Hayes and

his associates (Hayes and Meltzer, 1972; Hayes, Meltzer and Seivers, 1972) has attempted to show that temporal information (in terms of the sheer volume of talk over time) is a significant factor in interpersonal judgments on the dimensions of dominance and affect (which they posit to be the primary interpersonal dimensions). Thus, it can be seen that temporal analysis plays an important role in the analysis of social interaction through the ability it gives the researcher to see patterns of behavior and the relationships between them.

There is considerable controversy as to the generalizability of stochastic process models to the study of social interaction. The objections are based on the arguments of such critics as Chomsky (1957) and Scheflein (1968) that language behavior and the non-verbal aspects of social interaction are not probabilistic in nature. They contend that Markov processes cannot account for complex language behaviors and that the nature of such behavior is certain in its occurance and not probabilistic. Birdwhistle and others have extended similar analyzes to the nonverbal aspects of social interaction also. This limitation has been recognized by such researchers as Altmann (1965) and Jaffe, Feldstein and Cassotta (1967), while others such as Hayes and Meltzer (1972) have sought to overcome it by arguing that sheer physicalistic cues can give adequate basis for interpersonal judgments, thus reducing the need for linguistic analysis.

However, the role of temporal analysis in social interaction research is trivial or redundant unless social interaction is probabilistic in nature. To the extent that interactive behavior can be shown to be generalizable over time and independent of other peoples behavior then the information provided by temporal forms of analysis is trivial and redundant to more generalizale

forms of statistical inference. There are really two problems here: 1) the problem of the independence model of behavior and 2) the accuracy of more generalizable forms of methodology such as ANOVA and regression to deal with social interaction. The independence model of behavior can be directed to the question of independence from the behaviors of other people and independence from one's own preceding behaviors. Jaffe and Feldstein (1970) in their research on the temporal patterns of speech have tested a model that assumed that partners in a dialogue were dependent in that they could be treated as a single source against a model where they were independent as separate sources. This research showed that the single source model provided better approximations of the observed frequencies than the separate source model in both the four-state and six-state versions. Hayes, Meltzer and Wolf (1970) found that evidence for independent models of behavior was dependent upon high sampling rates which produced a higher percentage of non-transition states. In terms of the independence of behavior from past behavior, social researchers have found zero-order models of probability to be highly inadequate to predict the following states of behavior. Jaffe, Cassotta, and Feldstein (1964) began their research with the assumption that successive samples of speech were statistically independent, but found that it yielded poor approximations to the actual states of speech. Altmann's (1964) work with the social communication of primates started with an zero-order Markov model, but moved to higher approximations to gain greater reduction in uncertainty. Thus, in terms of social interaction, a probabilistic dependency model has proved to be superior to an independence model in the prediction of behavior.

More generalizable forms of statistical analysis such as regression and

analysis of variance have proved to be too gross when dealing with social interaction. Hayes, Meltzer, and Lundberg (1968) used analysis of variance to find that the information possessed by the partner in a discussion was the only significant variable determing amount of talk in a task conversation. However, when the relationship was examined using time intervals it was found that the relationship and dependence varied at different times in the conversation. Meltzer, Morris and Hayes (1971) found that interruption outcomes were determined by two variables: the change in defender's amplitude and the difference in amplitude between the two contestants. However when the stepwise regression results were subjected to a time sequence analysis, it was found that changes in the defender's amplitude were a good predictor for only short interruptions while the difference in contestants' amplitude proved to be the stronger predictor for interruptions of longer duration. Thus it can be seen that the probabilistic analysis of time provides a better picture of the relationships between behaviors in social interaction than more generalizable forms of analysis.

The temporal analysis of social interaction can be used to examine three aspects of behavior as it occurs over time: 1) frequency, 2) duration, and 3) intensity. The first of these aspects has been used quite frequently in the study of social interaction, and as a result will receive the largest amount of attention in this paper. The second has been the subject of some recent interest, and the third has only received marginal attention.

Temporal Frequency

Rapoport and Chammah (1965) have explicated the logic behind the use of frequency measures or as they are more commonly called time series and stochastic analysis. They argue that the subjective nature of social

science data makes the scale used in measurement highly important. As a result the measurement of relative frequencies becomes highly important because an absolute or ratio scale is used which makes the units more reliable and generalizable. When measuring the relative frequency of an event, it must be defined operationally in relationship to a population of events, thus when dealing with the probability of a single event, its definition must be theoretical because no operational comparison good exists. A stochastic model of a process represents the relations among various probabilities and their changes that come about over time. Thus stochastic models provide theoretical approximations of the relative frequency of observed events.

A primary application of such a stochastic time m odel to social interaction has been the linear learning theory models proposed by such people as Bush and Mosteller (1965), Estes (1950), and Suppes and Atkinson (1960). Suppes and Atkinson (1960) have even extended their model to social interaction situations, but still concentrate on the primary effects of individual learning as it affects interaction. These models form the basis for some of the later social interactive models which utilize Markov processes (Jaffe, Feldstein, and Cassota, 1967 where the main difference is in the sampling unit utilized).

The uses and implications of a linear Markov model of time series analysis are best illustrated by Altmann's (1965) work. He has gathered an extensive amount of data on the behavior of rhesus monkeys based on an observation system he has constructed. His basic method of analysis consists of studying the sequential contingencies among behavioral events by constructing models of behavior built on sets of probabilities that specify

the liklihood of each possible behavioral outcome in a social interaction. Each new model includes an additional factor which is tested for a significant influence upon the reduction of uncertainty in prediction. Using this method he has built fourth order approximations of social behavior which yield estimates of the amount of uncertainty, the reduction in uncertainty, and the degree of stereotypy.

The conclusions that Altmann draws from such a temporal model of social interaction reveal linear patterns of probabilities where the likelihood of one behavior following another are specified. Altmann sees the primary application of stochastic models to human interaction as lieing with metacommunication because such processes exhibit the contingent nature of stochastic analysis (Altmann, 1967).

A specific model of speech behavior has resulted from Jaffe and Feldstein's work with temporal aspects of speech states. They have created their single source model of monologue and dialogue on a Markov model of transition probabilities from states of silence to states of talk. Jaffe, Casotta, and Feldstein (1964) created a two state (silence and speech), first-order Markov model of monologue where the analysis is based on units 30 microseconds in length. Jaffe, Feldstein, and Casotta (1967) extended this model to a four state (four combinations of silence and speech for two participants), first-order Markov model of dialogue. Such a model allowed them to deal with the phenomena of speaker switching and speaker pauses, but failed to fully differentiate between the roles of encoding and decoding. As a result of this failure, Jaffe and Feldstein (1970) expanded their model to a six-state, first-order Markov model of the probabilities involved in dialogue. In this model they subdivided the mutual silence and simultaneous

speech states into ones where interactor A or B was designated as holding the floor. They justified this expansion by showing that the probabilities of one person speaking after a mutual silence are different if he has held the floor in a mutual silence (defined by who has held the floor through speech previous to the silence) than if the other person has held the floor during a mutual silence.

Such a model of social interaction implys that the state of social behavior in terms of speech and silence can be predicted from a knowledge of the frequency of one behavior following another. For Jaffe, Feldstein and Casotta (1967), such a model of social interaction means that speaker switching is an emergant property of dialogue, that the individuality of speakers can be submerged into the "single source" and that accurate prediction is possible from such a model. While some of these conclusions may seem trivial, Jaffe and Feldstein see a heuristic value in the ability of the model to account for these phenomena. However, while the model may account for these conclusions, it may also limit the conclusions obtained.

One important variable in the kinds of behavioral patterns that are obtained by stochastic time series models is the criteria used for determining the order of approximation for the model. Altmann (1965) has proposed the criterion of whether a higher order significantly improves the reduction of uncertainty in prediction. However, in Jaffe and Feldstein's 1967 and 1970 work, they reject a second-order model that significantly improves the predictability of the probabilities. They base this on the argument that "speaker switching" is adequately accounted for by the first-order model in terms of correlations, and that it involves fewer "free parameters". This last argument has been used by Rapoport and Chammah (1965) also when they

argue that the less the number of free parameters, the more generalizable the predictions made by the model. The importance of these distinctions in criteria are that one (the greater predictability criterion) will tend toward higher order models while the other (the fewer parameters criterion) will tend toward lower order models. When lower order models are used, the patterns of behaviors are liable to be rather limited, whereas when higher order models are used, the sequences of behaviors are likely to form longer chains. Thus, a trade-off exists between the generalizability of a model (in terms of parameters) and the detail of relationship and accuracy of approximation (in terms of predictability).

The relationship between a measurement model such as time series analysis and the substantive conclusions that can be made about social interaction has been best illustrated by Hayes, Meltzer, and Wolf (1970). In the first part of their study they took time series speech data and defined it in terms of three types of sampling units: 1) EU's, elementary units, which are units sampled at 1/6 of a second, 2) XUs, extended units, which are sets of consecutive unchanging EUs, and 3) CUs, composite units, which are units composed of pairs, triplets or larger combinations of XUs. For EUs and XUs, the predictive power of a first-order model was not significantly improved by higher order approximations, whereas for CUs second and third orders of approximation yielded significantly higher predictive power than a first-order model (the third-ordermodel for CUs produced the strongest approximation to the observed data). The implication of these results for substantive conclusions about social interaction is that a strong interaction can occur between the order of the temporal model used and the nature of the data (and by extension the criterion used in selecting order of approximation in accounting

for distributions).

In the second part of their study, Hayes, Meltzer and Wolf (1970) tested the effect of sampling rate on the type of conclusionary model resulting from similar Markov chain analyses. Using the maximum likelihood method of estimating conditional probabilities, they obtained a set of probabilities that approximated an independence model for their data and a set of probabilities that approximated a social dependence model for data from Jaffe, Feldstein and Casotta (1967). The main difference in the analyses lay in the faster sampling rate of the Hayes-Meltzer data which caused a higher percentage of the sampled units to be in the non-transitional states thus producing a model that stressed independence of probability states. The implication of such differences for the relationship between social interactive behaviors that is posited on the basis of a stochastic time series model is that great variation in conclusions can result.

It has become clear that time series analyses of temporal frequencies have limitations that can affect the types of conclusions drawn from them. Moreover, two criticisms have been made of the appropriateness of stochastic models for social interaction research. First, stochastic models have been objected to because of their linear nature. Chomsky (1957) and others have argued that patterns of social interaction (particularly language) may have nested behaviors that cannot be detected in a linear model. Hayes and Sievers (1972) have criticized linear models which focus on the probability of high and low participation leading to certain interpersonal judgments solely, and have proposed a parabilic model to account for the patterns of interaction that they see. A large part of their criticism rests on the

idea that certain statistical methods such as factor analysis and stochastic analysis will by their nature yield linear models of behavior. Thus, the linear assumption of most stochastic processes should be understood before use is made of such methods of analysis.

Second, as pointed out by Altmann (1965), this type of model assumes that the state relationships remain stationary while they are being sampled. If the state relationships are changable, then a whole different type of analysis is involved which centers around what is known as the erogodic processes.

Temporal Duration

The second aspect of time that can form the basis for temporal analyses is duration which is usually known as time sequence analysis. Whereas time series analysis was concerned with the relative frequency of occurance for behaviors in set time units, time sequence analysis is concerned with the distribution of exact times at which particular events happen. Time sequence analysis takes place on an ordinal scale of measurement that can only specify the relative occurance of behaviors and their temporal occurance.

The Meltzer, Morris and Hayes (1972) study on interruption outcomes shows the heuristic value of time sequence analysis in its ability to explicate the relationship between two significant variables. The relationship of the significant variables to the duration of time showed different functions for each variable in the outcomes of interruption. However, this form of analysis could not tell the probability of one form of behavior or another occuring at any given point in time.

Bobbitt, Gourevitch, Miller and Jensen (1969) have developed a program that looks at both simultaneous occuring patterns of behavior and mutually exclusive sequences of behavior patterns. These analyses allow the researcher to find patterns of behavior that occur in short periods of time and sequential patterns that occur more often than chance. This type of analysis has allowed Jensen, Bobbitt and Gordon (1967) to observe patterns of behavior and their changes over periods of time. For example they will look at the behavior of a mother primate and the following behavior of the infant and observe changes in the duration and frequency of this type of behavior pattern over time.

Rosenfeld (1973) has utilized forms of time series and time sequence analysis to form histograms which show the frequency of behavior and the distributional patterns of time at which events occur. One form of time sequence analysis utilized by Rosenfeld is the "relational histogram." It determines the temporal relationship between variables by translating time series data into time sequence data (with a series of criteria for inclusion) and testing the typical location of a variable between successive occurences of a second variable. This form of analysis allows him to view the behavior patterns of individuals and examine the duration of time associated with them.

Time sequence analysis has proved to be more adaptable to the analysis of interpersonal structures of behavior because of the temporal associations it shows between social variables. Out of it larger multivariate systems can be built, but these systems lack a certain comprehensiveness because they are usually built out of smaller units of analysis (such as 2 by 2 chi squares in Rosenfeld's work). This particular problem was illustrated by

Hayes, Meltzer and Wolf (1970) when they tested time series and time sequence models for the same data. They found that the time sequence model required a higher order approximat on to predict the data than the the time series model, but that time sequence provided a better approximation of the observed data. Because of the smaller units of analysis used in the time sequence model, it was necessary to link more units to model the system effectively (which naturally gave a higher order model). Some researchers have attempted to overcome this problem by providing for larger units of analysis. However, this approach tends to yield cumbersome and expensive systems of analysis (such as in the work of Bobbitt). Some researchers have constructed more molar units from time series patterns and arbitrarily treated the derived units as fixed time units in the determination of sequential dependencies. However, these processes are essentially pseudo time series and not time sequence in that they ignore the real timing of events.

Temporal Intensity

Intensity refers to the strength, magnitude and level of some behavior as it occurs over time. Its place in the temporal analysis of social behavior patterns has been pointed out by Altmann (1965), but the operationalization of the concept has not really occured. The Meltzer, Morris and Hayes (1971) study of interruption outcomes and amplitude can be interpreted in light of this construct. But while, it may have served as a variable in research, it has not yet generated a unique methodlogy for its analysis. This lack may be accounted for in two ways. First, the primary emphasis of social interaction analysis has been upon behaviors which are usually thought of as occuring or not occuring. Such a view leads to a primary

emphasis upon frequency of occurance, secondary emphasis on duration of behavior, and only a tertiary emphasis on the strength of one behavior compared to another of the same kind. Thus, for more emphasis to be placed on intensity it will be necessary to view social interaction in more of a analogic fashion and less in a digital fashion.

In summary, we have seen that a close relationship exists between the methods of temporal analysis and the substantive conclusions obtained in the analysis of social interaction. The different models used (especially the stochastic processes) have built-in limitations that need to be taken into account by those who use them. However, the temporal methods of analysis have proved valuable to the study of social interaction despite their limitations.

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